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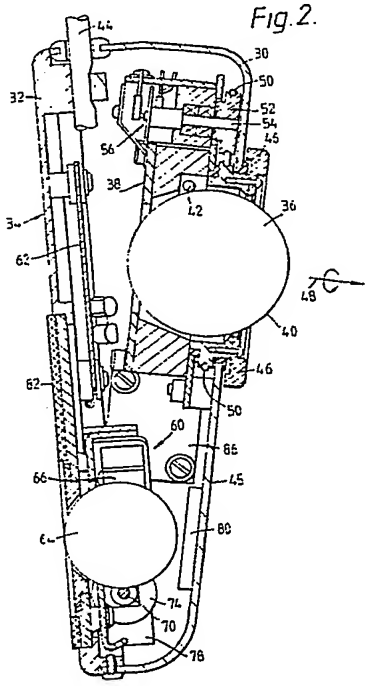
(54) User input device for an interactive display system

(57) The user input device comprises a body (30, 32) on which are mounted first input means, eg. tracker ball (36) or joystick, by which hand movements of a user relative to the body are translated into a first control signal variable in at least two dimensions and second input means (64) eg. of the "MOUSE" type by which movement by the user of the body in two dimensions across a reference surface against which the body rests is translated into a second control signal variable in two dimensions. The device enables the generation of two independent, multi-dimensional control signals, avoiding or reducing problems associated with the control for example of 3-D image synthesis display apparatus by means of known user input devices. The first input means may be surrounded by a bezel (46, Figs 5, 6) which is rotatable by the user's fingers to generate further control signals.

Fig.2.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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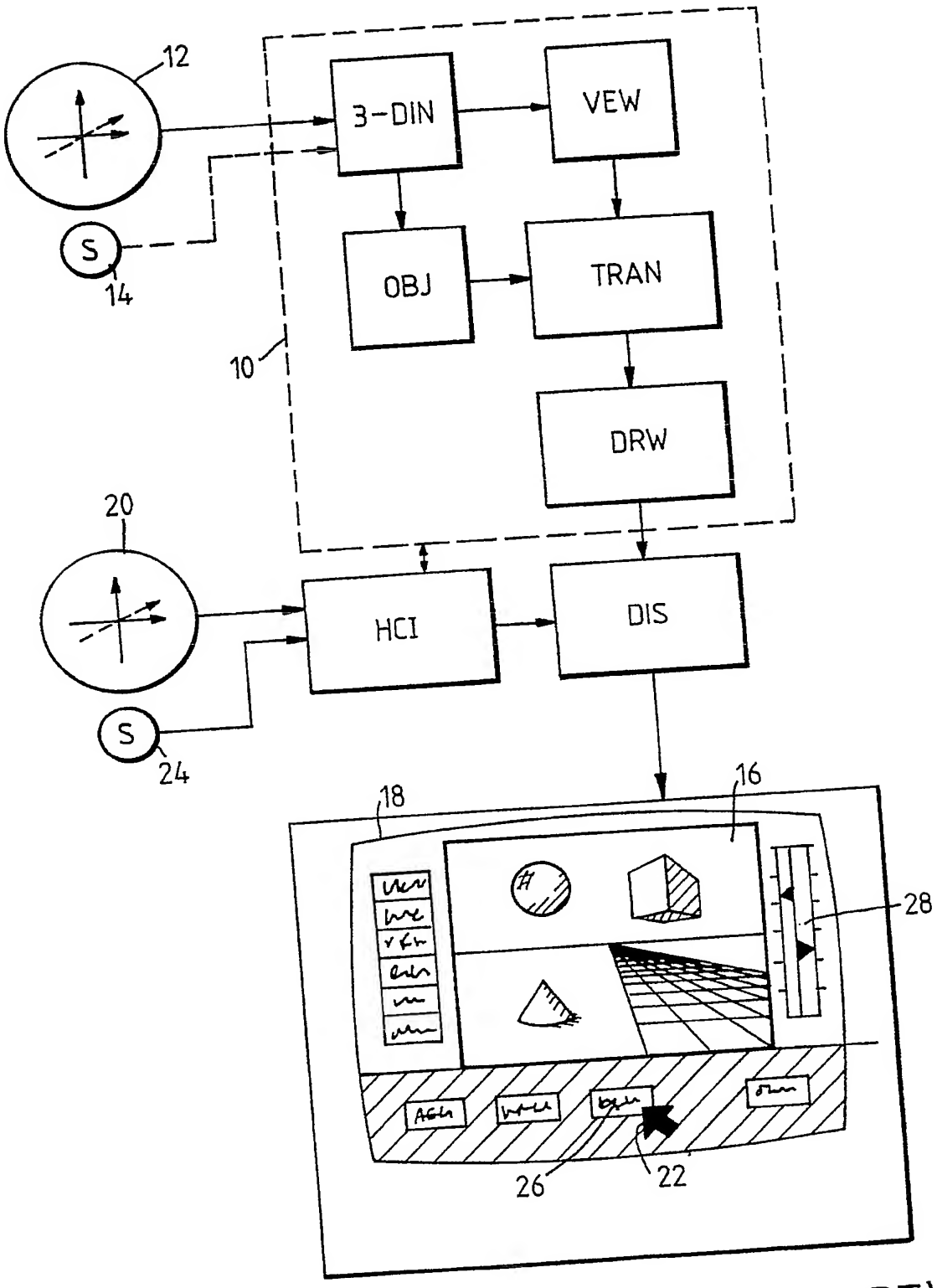


Fig.1. (PRIOR ART)

1-V- PHB 33575

Fig. 2.

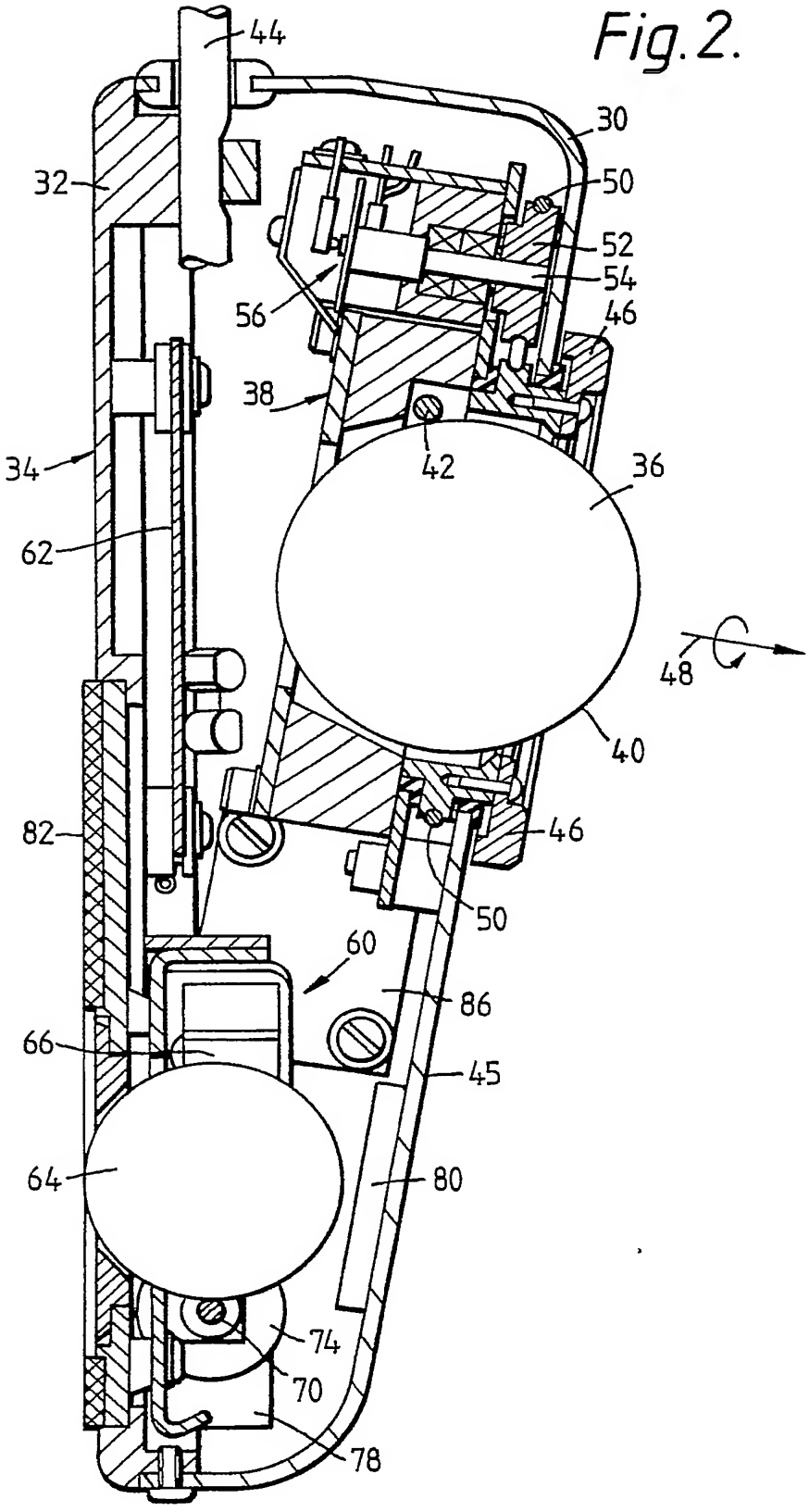
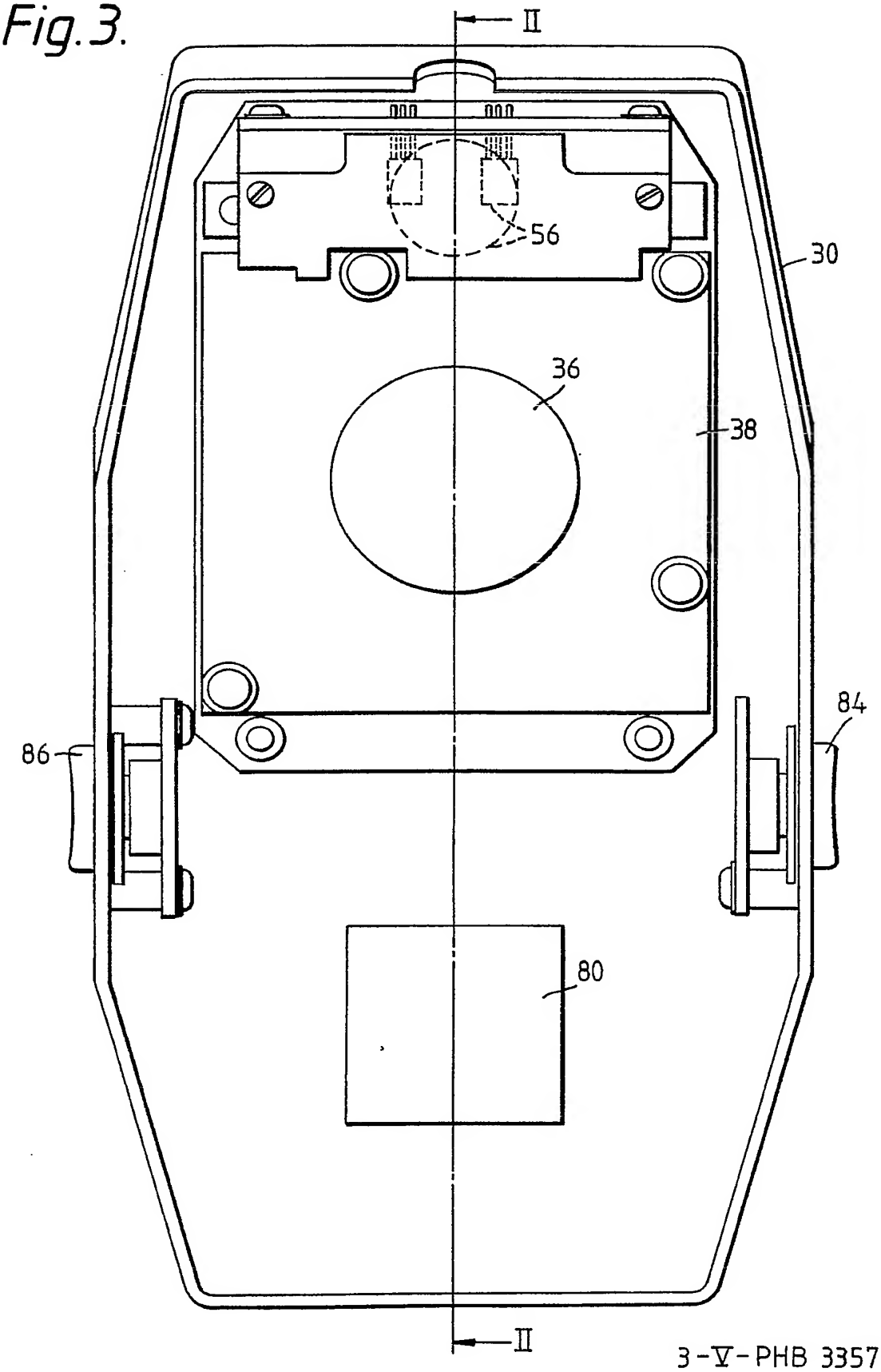
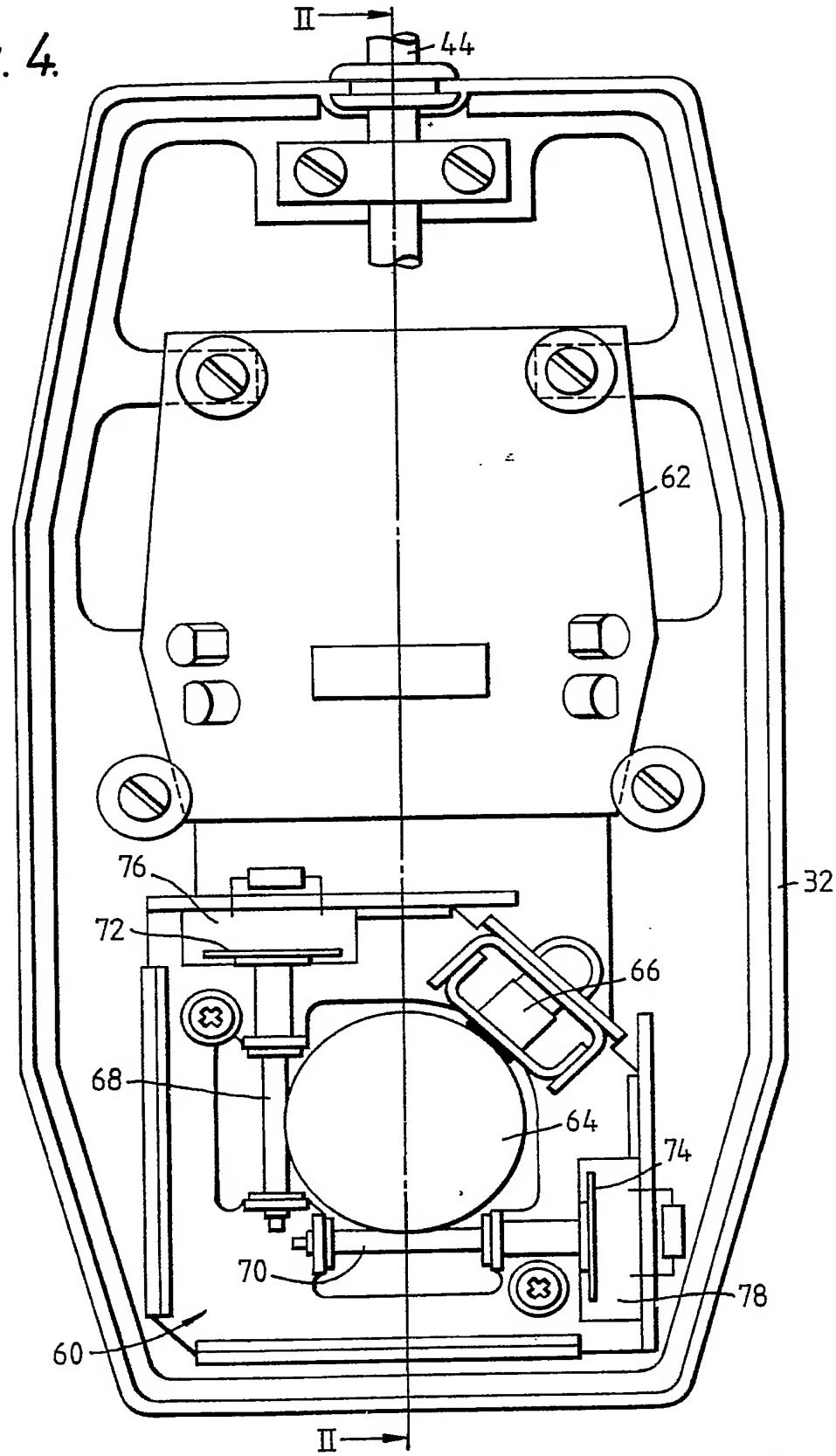


Fig.3.



3-V-PHB 33575

Fig. 4.



4-V-PHB 33575

Fig. 5.

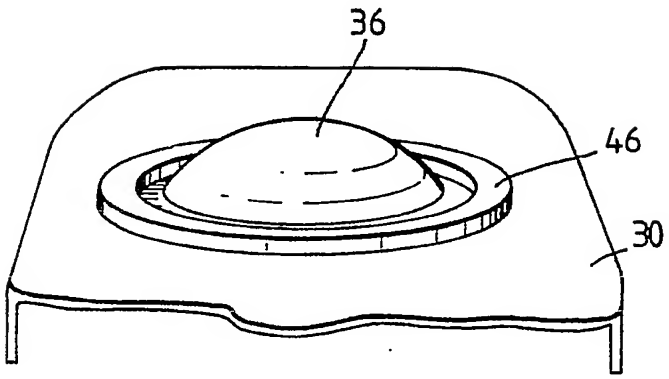
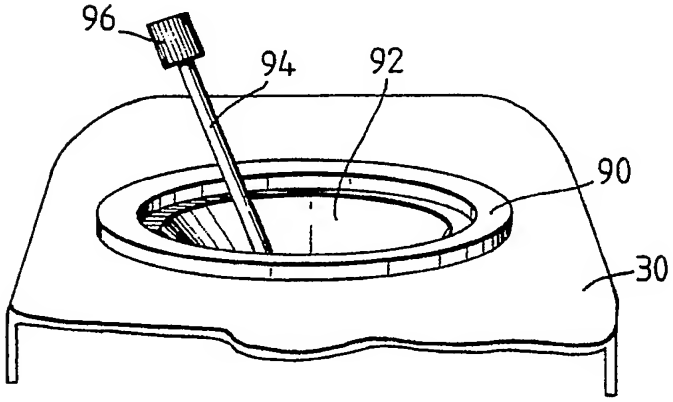


Fig. 6.



DESCRIPTION

USER INPUT DEVICE AND DISPLAY SYSTEM INCLUDING SUCH A DEVICE

The invention relates to a user input device for an interactive display apparatus, the device comprising a body on which are mounted first input means by which hand movements of a user relative to the body are translated into a first control signal variable in at least two dimensions.

The invention further relates to an interactive display system comprising:

- first input means comprising a user input device as set forth in the preceding paragraph, second input means and signalling means;
- three-dimensional (3-D) modelling means for defining a set of objects in a 3-D object space;
- transformation means for generating representations of the objects in a viewer space;
- scene display means for displaying the representations of the objects in the viewer space;
- scene control means responsive to a scene control signal received from one of the first and second input means for manipulating the objects in the object space and/or moving the viewer space relative to the object space;
- system control display means for presenting in a two-dimensional form a number of different system control options;
- selection control means responsive to a cursor control signal and a selection control signal, received from the other of the first and second input means and the signalling means respectively, by means of which selection control means the user can point to and select a desired one of the system control options.

Input devices of the type set forth in the opening paragraph come in various forms, common examples being tracker balls, joysticks, and simple arrays of two or more potentiometers. Such multi-dimensional input devices are of particular use as the

scene control input device in interactive display systems as set forth in the second opening paragraph which are known and used in the fields of computer-aided design (CAD), education and entertainment.

The cursor control means forms part of a menu-and-pointer type user interface for higher-level control and may conveniently but not necessarily share a common display device with the 3-D scenes. An input device as set forth in the opening paragraph could also be used as the input means for cursor control. Alternatively, the input means for cursor control might comprise for example a so-called "mouse" or a digitising tablet. A common problem in either case is that the table-top space required for the mouse or other cursor control device conflicts with the space occupied by the tracker-ball or other scene control device, and the user is inconvenienced greatly by having to move his/her hand continually between two different devices.

A known solution to these problems is to provide means for switching the system between two modes so that a common input device can act in one mode (scene control) to control the various 3-D manipulations and in another mode (cursor control) to control the movements of the menu pointer and so on for higher level control. A disadvantage with this known solution is that a signalling button on the input device is permanently occupied (at least in the scene control mode) with the mode-switching activity. Another problem is that the user commonly forgets which mode the device is in, and commits errors which even at the least are a waste of time and a source of irritation to the user.

It is an object of the invention to provide a user input device with which some or all of the above disadvantages can be overcome.

The invention provides a user input device for an interactive display apparatus, the device comprising a body on which are mounted first input means by which hand movements of a user relative to the body are translated into a first control

signal variable in at least two dimensions, characterised in that the device further comprises second input means by which movement by the user of the body in two dimensions across a reference surface against which the body rests is translated into a second control signal also variable in at least two dimensions. In such a device, two input means are combined in a single unit and yet they are able to operate independently without the need for mode-switching and without the risk of confusion arising therefrom.

The second input means in such a device is useful particularly, but not exclusively, for cursor control since movement across a two-dimensional surface (such as a table-top) can be related very easily in the mind of the user to resulting movements of a cursor over a two-dimensional screen display.

The second input means may also be mounted in the body and may comprise a ball protruding partially through an opening in the body, which ball can be rotated relative to the body by frictional contact with the reference surface, and means for detecting such rotation with respect to two orthogonal axes fixed with respect to the body and substantially parallel to the reference surface when the device is in use. This form of input means can be the same as that used in the conventional mechanical type of mouse input device, giving a simple and low-cost construction and compatibility with an existing mouse interface.

Alternatively, the second input means may comprise optical sensing means for detecting movement of the body using reference marks provided on the reference surface. This second input means is similar to a conventional electro-optical type of mouse in which there are no moving parts and a particularly compact construction can be obtained.

The device may further comprise signalling means located on the body whereby a user can with a single hand move the body to alter one or both of the first and second control signal and at the same time generate selection control signals to initiate further processing of selected values of the first and/or second

control signal. Signalling means, for example one or more push-switches, can allow selections of display items pointed to by a cursor, mode changes and other useful facilities, all under control of a single hand. Where signalling means are provided for use in association with the second input means, the signalling means may comprise at least one switch located on a part of the body which in use is inclined or substantially perpendicular to the reference surface. This may avoid the positioning of the signalling means interfering with that of the first input means, while enabling the switch(es) to be positioned within reach of the user's fingers while the body is being moved over the surface to operate the second input means.

In principle, any form of two-or-more dimensional input device may be mounted on the body to form the first input means. In some embodiments, the first input means comprises a control element projecting through an aperture in the body so as to enable the generation of the first control signal in response to hand movement in two dimensions relative to the body. The control element may for example comprise a joystick, the first input means comprising detectors responsive to deflection of the joystick in two orthogonal directions. It should be noted, however, that substantial movement of the control element is not essential; it may be sufficient to detect the force of hand movements without the control element itself moving.

In another such embodiment the control element of the first input means comprises a ball, rotatably mounted within the body and partially protruding through an aperture in the body and the first input means comprises detectors for detecting rotation of the ball about two orthogonal axes to provide first and second dimensions to the first control signal.

In such embodiments, the first input means may further comprise a rotatable element surrounding or partially surrounding the aperture, and a further detector for detecting rotation of the element around the periphery of the aperture to provide a third dimension to the first control signal. The rotatable

element may comprise a ring surrounding the aperture.

The invention further provides an interactive display system of the type set forth in the second opening paragraph, characterised in that the first and second input means and the signalling means are formed by a user input device in accordance with an embodiment of the invention as set forth above.

In particular, the scene control means may be responsive to a control signal generated by the first input means and the cursor control means are responsive to a cursor control signal generated by the second input means.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows schematically an interactive display system including first and second input means;

Figure 2 is a cross-sectional view of through an input device in accordance with one embodiment of the invention;

Figure 3 is a view from below of an upper part of the input device of Figure 2; and

Figure 4 is a view from above of a lower part of the input device of Figures 2 and 3;

Figure 5 is an external perspective view of part of the input device of Figures 2 to 4; and

Figure 6 is an external perspective view of a similar part of an input device in accordance with another embodiment of the invention.

Figure 1 shows schematically a system for the display of images representing 3-D objects. A group 10 of modules comprises a module OBJ for storing and managing a database forming a model of a 3-D environment, the "object space", containing various 3-D objects, each modelled for example as a group of polygonal surfaces, which in turn are defined by vertex coordinates and surface characteristics (colour, texture, transparency etc.). Positions and other attributes of light sources may also be defined. Another module VEW defines a "viewing space", for

example in terms of the position of a viewpoint, the direction of view and the field of view.

A scene control input means 12 provides control in two or more directions simultaneously so that the user can manipulate or modify objects within the object space or manipulate the viewpoint, direction of view and other attributes of the viewing space. The input means 12 comprises transducers for converting the user's hand movements relative to a body of the input device into signals which can be interpreted by an interface module 3-DIN. Many forms of two-dimensional input means are known for this purpose, including tracker balls, joysticks, electrostatic, electroacoustic and electromagnetic digitising tablets, and many of these can be extended with controls such as potentiometers for further degrees of freedom, and with signalling buttons 14 for mode-changing commands. Another form of input device known as a "knob box" comprises a box on which is mounted an array of potentiometers, one for each degree of freedom which it is desired to control, often as many as nine.

A module TRANS performs geometric transformations to translate the various coordinates in object space defined by the module OBJ to equivalent coordinates in the viewing space. These transformations will generally include translation, rotation and perspective, as is well-known in the art. In the case where the display is only two-dimensional coordinates in the viewing space in two dimensions (typically called x and y) will correspond linearly to screen coordinates, while a third coordinate (z) corresponds to the "depth" of an object "into" the screen.

The module TRANS passes the viewing space coordinates and surface attributes to a rendering module DRW which converts the viewer space information into a form suitable for display, typically by scan conversion into pixel values in a bit-mapped display memory DIS. The rendering module DRW may perform calculations for hidden-surface removal (using the z coordinates), lighting, shading, anti-aliasing and clipping to the screen boundaries in a manner well-known in the art.

The display memory DIS is mapped onto a window area 16 of a display screen 18. A control module HCI uses the remainder of the screen 18 to display menus of control options, and receives position signals from a cursor control input means 20 which enable the display of a cursor 22 at locations selected by the user. The cursor control input means 20 could comprise any of the two-dimensional input devices mentioned above as being suitable for use as the scene control input means 12. However, it is also possible to use a kind of device which is movable bodily relative to a stationary reference to generate the required signals. Examples of such devices are the mechanical and optical types of "mouse", which detect movements of their bodies over a relatively passive reference surface such as a table top. Other such devices are the electromagnetic, electroacoustic and electrostatic types of digitising tablet, where the reference surface forms a more an active component. These devices are particularly convenient for pointing by cursor movement, since the user can readily equate hand movements over a flat surface to the resulting movements of the cursor over the screen. A type of input device suitable for cursor control and which responds to hand movements relative to the device body is described in European Patent Application EP-A2-0320044. Such devices may also be used as the scene control input means 12 in place of the devices mentioned above in that context. Signalling means 24, typically comprising one or more push button switches, are also mounted on the body so that the user can indicate that a menu option (26) to which the cursor 22 is pointing when the button is pressed is being selected.

The menu options displayed may enable various global parameters of the object space or the viewing space to be adjusted. "Sliders" displayed (at 28, for example) may be convenient for this purpose and also, for example to allow the altitude of the viewpoint to be adjusted if this is not possible using the scene control input means 12. Other options may allow the creation or addition of new 3-D objects, a change to a

different model, file management functions and so forth. It will be understood that the significance of the signals generated by scene control input means 12 can thus vary in accordance with different modes of operation activated using the cursor control input means 20.

The various elements of the system illustrated as described so far and their functional relationships are conventional, and can remain conventional in a system in accordance with the invention. However, the problems created for the user in manually operating both input means 12 and 20 can be reduced in accordance with the invention by adopting a novel construction of input device in which both input means 12 and 20 are combined in a single unit. One such device is illustrated in Figures 2, 3 and 4.

Figure 2 shows the device in cross-section. A housing of the device comprises upper and lower body parts 30 and 32 respectively. The face 34 of the lower body part 32 which faces towards the left hand side of Figure 2 rests on a table top or other reference surface when the device is in use.

Describing the upper body part 30 first (Figures 2 and 3), this houses a first input means including a control element in the form of a tracker ball 36 and an associated mechanical and opto-electronic sub-assembly 38. The construction of such a sub-assembly is well-known. In essence it comprises two rollers with orthogonal axes biased against the surface of the ball 36 so as to rotate when the user rotates the ball about a corresponding axis by pushing against the part 40 of the ball's surface which protrudes through the body part 30. One of the rollers can be seen in cross-section at 42. Optical encoders translate the roller rotations into movement signals which are transmitted to the display apparatus via a cable 44 which leaves the device in a direction away from the user. A resting area 45 is provided to take the weight of the hand while the fingers manipulate the ball 36.

For convenience, the tracker ball 36 and sub-assembly 38

could be taken from a commercially available tracker ball input device. One such is available in the United Kingdom from RS Components Limited under the Stock number 650-964. Other types of first input means such as those already mentioned could be provided instead of the tracker ball assembly, and could likewise be taken from a suitable commercially available device. A joystick mechanism for example is available commercially from RS Components Limited under Stock Number 162-732.

The commercially available tracker ball assembly 36/38 has been enhanced in the device shown to provide a third degree of control. To this end, a bezel 46 surrounding the ball 36 where it protrudes through the body part 30 is journalled so as to be rotatable about an axis 48 which is orthogonal to the roller axes about which the ball rotation is detected by the rollers. The bezel is grooved to receive and engage a drive belt 50 which connects it to a pulley 52 which in turn drives the shaft 54 of an optical encoder assembly 56. Such encoder may conveniently be of the same form as those in the tracker ball or mouse. The bezel 46 can be rotated conveniently by the same hand that controls the ball 36, in response to which signals are generated by the encoder 56 and transmitted via the cable 44 to the display apparatus. Wireless transmission rather than cable transmission would also be possible of course, for example by a modulated infra-red signal. It may be noted that all signals transmitted by the device to the display apparatus may be of a conventional form, so that interfacing with existing display apparatus is not a problem.

Figure 5 shows part of the exterior of the device including the tracker ball 36 and the rotating bezel 46. It will be seen that a slight opening of the fingers of a user's hand will put them in a position for moving the bezel 46 while the main part of the hand remains substantially unmoved from its conventional position over the ball 36. The bezel 46 may be knurled on its top surface to provide a good grip. Further degrees of control could be provided by further rotary control elements concentric

with the bezel 46.

This enhancement is also applicable to other types of input device where a control element projects from an aperture in a housing so as to be movable by a user's hand, and is the subject of United Kingdom Patent Application No. 8917342 having the same application date as the present application. In the embodiment of the invention illustrated in Figure 6, a ring-shaped control element 90 is mounted so as to rotate around the aperture 92 through which a control element in the form of a joystick 94 projects, again to provide a third dimension of control in addition to the conventional joystick's two control axes. It may be noted that it is known to enhance a joystick by making a knob 96 at the end of the stick rotatable about the joystick axis to provide a third degree of control. The rotating ring 90 may be provided as an alternative to the known enhancement, or may be used in addition.

On the lower body part 32 (Figures 2 and 4) there are mounted mechanical and electronic sub-assemblies 60 and 62 of a second input means similar to the conventional mouse. A mouse ball 64 projects through the base 34 of the device and rolls over a table top or other surface upon which the device is resting in use. A spring arrangement 66 biases the ball 64 against two orthogonal rollers 68 and 70 which rotate as the ball 64 is rolled across the table top in two corresponding orthogonal directions. A pad 80 glued to the inside of the upper body part 30 prevents the ball falling out of place, while a sheet of felt 82 on the underside of the body allows it to slide smoothly over a table surface. Each roller 68,70 drives a respective optical interruptor wheel 72,74 and optical encoders 76 and 78 generate movement signals which are transmitted with the signals from the first input means via the cable 44. The sub-assembly 38 for the tracker ball 36, although not shown in detail, is substantially equivalent in operation to that of the mouse as just described.

To indicate selections from a menu and so forth, a cursor control input means such as a mouse is normally associated with

some signalling means such as one or more push button switches, conventionally located on top of the body of the mouse, where the user's fingers can operate them while moving the mouse across the table under the palm of the hand. However the top side of the present device is occupied by the tracker ball, and will tend to be similarly occupied even in other embodiments. The tracker ball or other first input means may also have associated signalling buttons which do need to be mounted on the top side of the housing, so that using this location for signalling means associated with the second input means could lead to confusion. The device therefore has signalling buttons 84 and 86 mounted on the inclined side walls of the upper body part 30 of the device housing.

These positions are particularly advantageous since when the user wishes to operate the second input means as a cursor control input means for menu selection and so forth, the hand will naturally shift from a forward position above the tracker ball to a position gripping the body in the region of the resting area 45, with the fingers and thumb extending down over the opposite inclined sides. Signals from the pushbuttons 84 and 86 may be transmitted to the display apparatus via the cable 44 in a conventional manner.

The mouse sub-assemblies 60 and 62 and the switches 84 and 86 can conveniently be taken from a commercially available mouse. One such is available in the United Kingdom from RS Components Limited under Stock number 650-942. Another is described in United States Patent No. 4 464 652. However, other types of mouse or other devices such as digitising tablet cursors could be incorporated into the device to the same effect.

One such variation which might be of benefit in the combined device is the so-called optical mouse, such as those described in United States Patents Nos. 4 346 035 and 4 546 347, the contents of which are incorporated herein by reference. The sub-assembly for an optical mouse can be made more compact than that of a mechanical mouse, since the ball and other moving parts are

replaced by a purely electro-optical system. This enables the complete device to be constructed in a housing very little larger than that required for the first input means alone. A drawback of the optical mouse technique is that the reference surface has to be marked with a special coloured grid.

From reading the present disclosure, other variations will be apparent to persons skilled in the art. Such variations may involve other features which are already known in the design, manufacture and use of display systems, user input devices and component parts thereof and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

CLAIMS:

1. A user input device for an interactive display apparatus, the device comprising a body on which are mounted first input means by which hand movements of a user relative to the body are translated into a first control signal variable in at least two dimensions, characterised in that the device further comprises second input means by which movement by the user of the body in two dimensions across a reference surface against which the body rests is translated into a second control signal variable in two dimensions.

2. A device as claimed in Claim 1 wherein the second input means is also mounted in the body and comprises a ball protruding partially through an opening in the body, which ball can be rotated relative to the body by frictional contact with the reference surface, and means for detecting such rotation with respect to two orthogonal axes fixed with respect to the body and substantially parallel to the reference surface when the device is in use.

3. A device as claimed in Claim 1 wherein the second input means comprises optical sensing means for detecting movement of the body using reference marks provided on the reference surface.

4. A device as claimed in any of Claims 1 to 3 further comprising signalling means located on the body whereby a user can with a single hand alter one or both of the first and second control signals and at the same time generate selection control signals to initiate further processing of selected values of the first and/or second control signal.

5. A device as claimed in Claim 5 wherein the signalling means comprises at least one switch located on a part of the body which in use is inclined or substantially perpendicular to the reference surface.

6. A device as claimed in Claim 5 wherein the at least one switch comprises a push switch operable by a user pressing a finger against the inclined part of the body.

7. A device as claimed in any of Claims 1 to 6 wherein the

first input means comprises a control element projecting through an aperture in the body so as to enable the generation of the first control signal in response to hand movement in two dimensions relative to the body.

8. A device as claimed in Claim 7 wherein the control element of the first input means comprises a joystick projecting from the body and the first input means comprises detectors responsive to deflection of the joystick in two orthogonal directions.

9. A device as claimed in Claim 7 wherein the control element of the first input means comprises a ball rotatably mounted within the body and partially protruding through an aperture in the body and the first input means comprises detectors responsive to rotation of the ball about two orthogonal axes to provide first and second dimensions to the first control signal.

10. A device as claimed in any of Claims 7 to 9 wherein the first input means further comprises a rotatable element surrounding or partially surrounding the aperture, and a further detector for detecting rotation of the said rotatable element around the periphery of the aperture to provide a third dimension to the first control signal.

11. A device as claimed in Claim 10 wherein the rotatable element comprises a ring surrounding the aperture.

12. A user input device substantially as described herein with respect to the accompanying drawings.

13. An interactive display system comprising:

- first input means, second input means and signalling means;
- three-dimensional (3-D) modelling means for defining a set of objects in a 3-D object space;
- transformation means for generating representations of the objects in a viewer space;
- scene display means for displaying the representations of the objects in the viewer space;

– scene control means responsive to a scene control signal received from one of the first and second input means for manipulating the objects in the object space and/or moving the viewer space relative to the object space;

– system control display means for presenting in a two dimensional form a movable cursor and a number of different system control options;

– selection control means responsive to a cursor control signal and a selection control signal, received from the other of the first and second input means and the signalling means respectively, by means of which selection control means the user can point to and select a desired one of the system control options;

characterised in that the first and second input means and the signalling means are formed by a user input device as claimed in any of Claims 5, 6 or 7.

14. An interactive display system as claimed in Claim 14 wherein the scene control means are responsive to a scene control signal generated by the first input means and the selection control means are responsive to a cursor control signal received from the second input means.

15. An interactive display system substantially as described herein with reference to the accompanying drawings.

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